OBSERVATIONS FROM AN ICEBERG IN FRESHWATER BAY, ST. JOHN'S

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C-CORE

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The Centre's mandate is to undertake research that will assist the safe and orderly development of Canada's resources in cold and ice frequented oceans.

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INTRODUCTION

A medium sized tabular iceberg was aground outside St. John's harbour for about two weeks in April, 1983. This berg and two others were located in extensive pack ice in Freshwater Bay. On April 15th eight researchers from C-CORE were landed on the berg by helicopter and carried out the several experiments described below. The winds were very light and an ocean swell was virtually subdued by pack ice producing ideal experimental conditions during our visit to this berg on our doorstep. In all, six experiments and observations were carried out during the two hour visit. These included measurements of: i) the internal temperature of the berg, ii) induced acoustic emissions and iii) keel profile using impulse radar; the sampling of: i) sediment-rich berg ice and ii) of crack ice; and observations of bergy bit motion.

General Description

The berg was approximately 190 m long by 120 m wide with a keel depth of 70 m (see **Impulse Radar Profiling**, p.7). The height above water was 10 m. Using the formula M = 3LWH the mass of the berg was calculated to be 684,000 metric tonnes where; M = Total Mass of berg in metric tonnes, L = longest dimension above water in M's, W = shortest dimension above water in M's, and H = height of highest point in M's. The surface of the berg was slightly undulose and the ice was generally saturated with meltwater. Pockets of water occurred in the numerous shallow depressions.

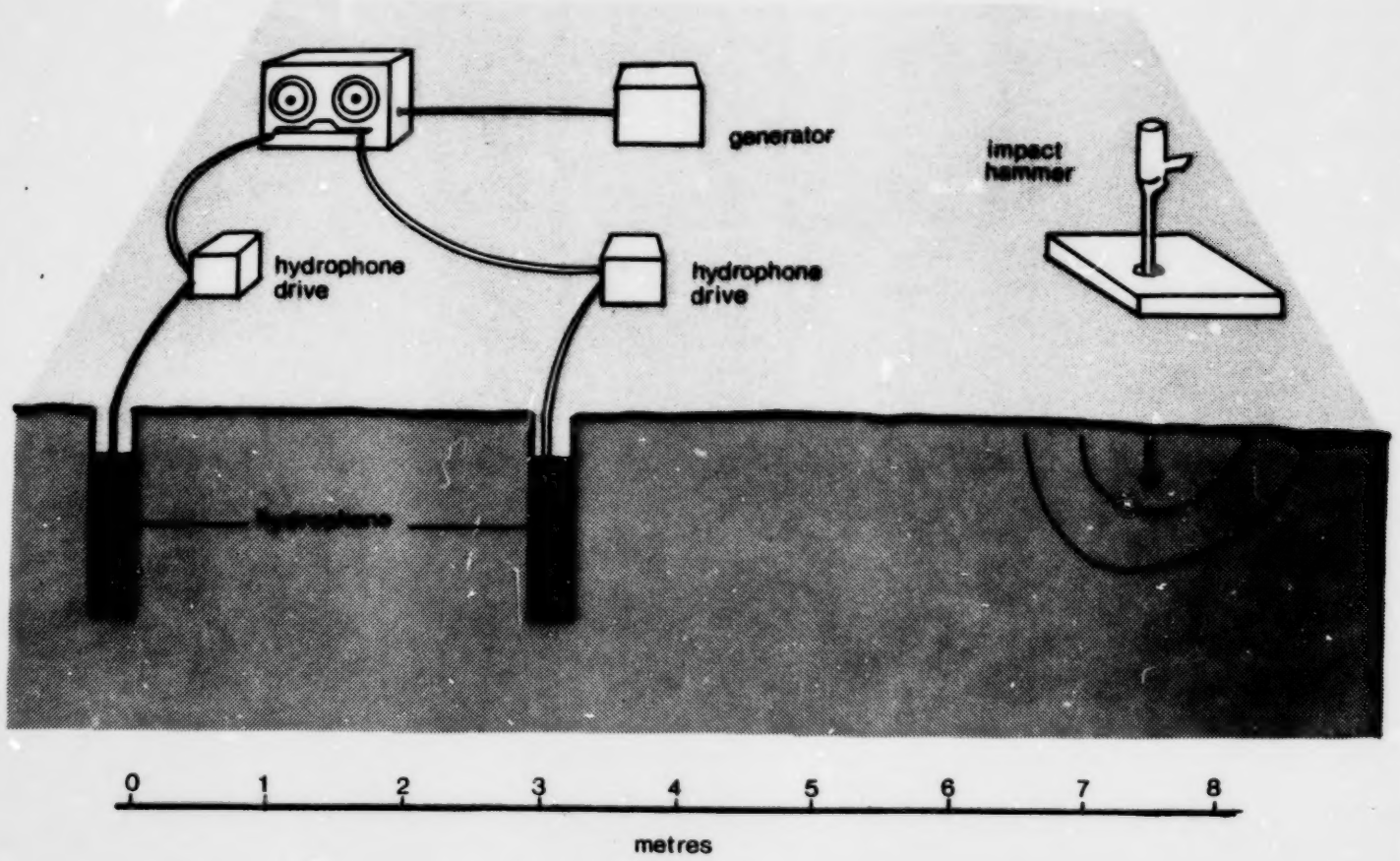

Figure 1 Acoustic Measuring Apparatus

ACOUSTIC TRANSMISSION IN ICEBERG ICE

Bruce Parsons

The acoustic measuring apparatus consisted of two hydrophones, two hydrophone drives, HP Instrumentation, an 8-Track tape recorder and impack hammer (Figure 1). Three sets of data were collected; the distance between the hydrophones varied from 1 m to 3 m. 85 mm diameter auger holes were bored to approximately .5 m below the surface. The holes were allowed to fill with water and the hydrophones were placed in the water. Three shots were fired with the impact hammer at every metre and the output from the hydrophone drives was collected on the tape recorder. Impact events in ice are reproducible neither in total power passed into the acoustic excitation nor in the frequencies excited, so firing a number of shots at each distance is desirable. The impact hammer was used because it excites a broader range of frequencies than a hand-held mallet. Comparing the signals at the two phones yields information both about the nature of the geometric spreading of the signal within the berg and about the frequency dependance of the attenuation.

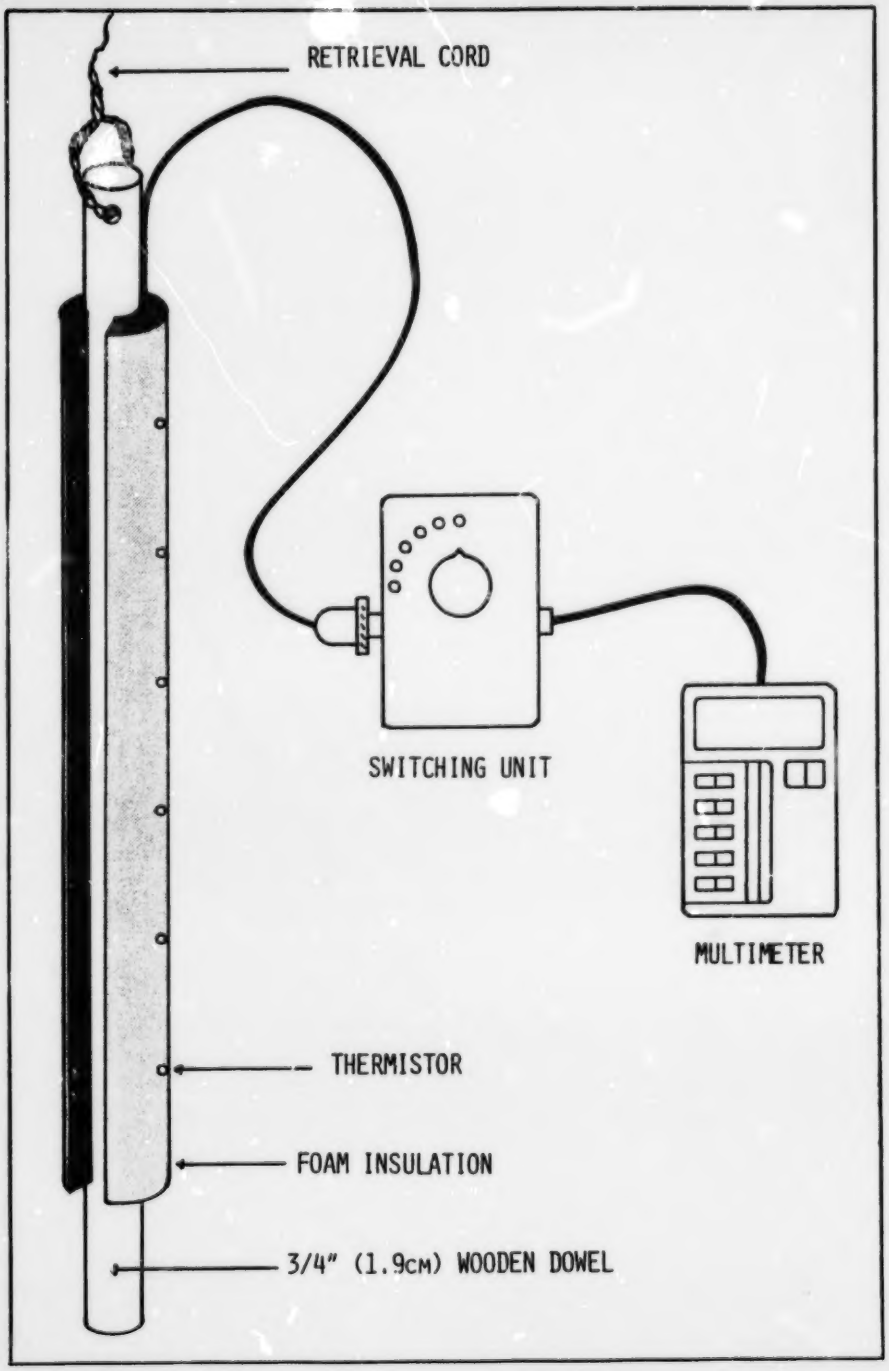

Figure 2 Thermistor Probe

ICEBERG TEMPERATURE STUDY

Deborah Diemand

A borehole temperature profile of the iceberg was obtained as follows:

A 4 cm auger was used to bore a vertical hole 1 m deep in the ice from the top surface. A thermistor chain (Figure 2) was pushed into the hole and readings were taken at five or ten minute intervals for 30 minutes. A second hole was bored nearby to a depth of roughly 2 m. At the end of 30 minutes the thermistor chain was moved to the second hole and pushed in as deeply as it would go. Again readings were taken every 5 to 10 minutes while the first hole was being bored to an increased depth of about 2.5 m. By alternating between 2 holes, it was possible to keep both the auger and the thermistor chain in the ice at all times, minimizing any warming which might have taken place had they been left on the surface for any length of time. As there was a considerable amount of water in pools and runnels on the surface of the berg, augering sites were chosen at slightly elevated locations. No water was detected in either of the holes.

The final readings for each of five depths are presented in Table 1. The unlikely readings from the 10 - 90 cm level are probably the result of both the auger and the thermistor chain being initially at ambient air temperature or higher; they had been removed from the helicopter a short time prior to these readings.

TABLE 1

Thermistor depth (cm)	Resistance	Temperature (°C)
10	8.95	1.78
30	9.27	1.09
50	9.37	0.88
70	9.62	0.36
90	10.08	-0.55
65	9.89	-0.18
85	10.33	-1.04
105	10.78	-1.85
125	11.19	-2.57
145	11.56	-3.20
140	11.26	-2.69
160	11.76	-3.52
180	12.16	-4.17
200	12.36	-4.48
220	12.79	-5.13
175	12.25	-4.31
195	12.64	-4.91
215	13.13	-5.62
235	13.42	-6.04
255	13.90	-6.70
270	13.88	-6.67
290	14.23	-7.14
310	14.70	-7.74
330	14.85	-7.93
350	15.26	-8.44

IMPULSE RADAR PROFILING

Ed Stander and Jan B. Snellen

Two profiles were taken of the Freshwater Bay iceberg, using a sled mounted G.S.S.I. electronics package coupled to two 300 MHz antennas. Adjustments on the system were as follows:

ADJ = 150	Mult = X2
GAIN = Min.	Filt = M
Sens = 100	Window = 10

Using the adjustments, we were able to get a "bottom return" signal at a depth of approximately 70 m. Associates with the signal were two other reflections located at approximately 70 m and 50 m each. Multiples of each signal were observed to a depth of approximately 210 m.

During this work, two profiles of the berg were attempted. These profiles extended across the long and short axes of the body. It was found that reflections were picked up at only 75% of these locations. Loss of signal return in the other locations may have been associated with difficulties involved in coupling the bathtub antenna to the ice sheet.

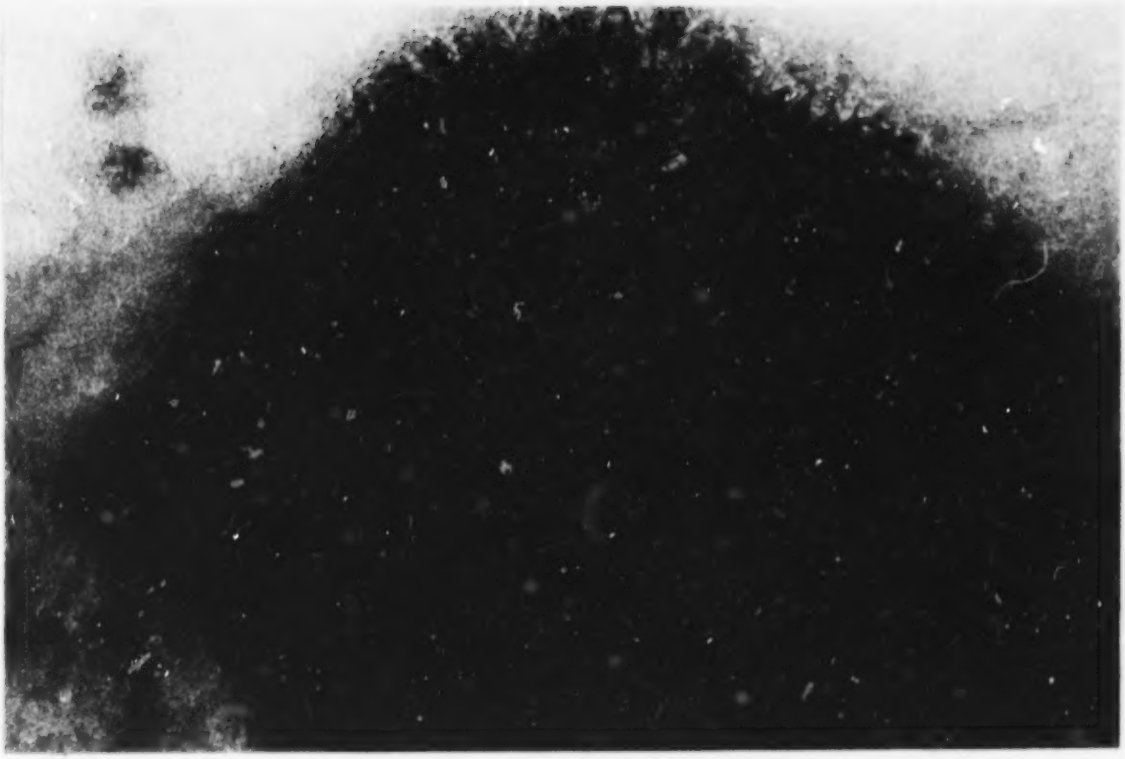

Figure 3 Circular hole with radial blue-ice crystals which have grown across the top. Holes like this always contained cryoconite, a flocced mixture of dust, algae and fungi.

SEDIMENT AND CRYOCONITE HOLES

Denny Christian and Chris Woodworth-Lynas

A thorough survey of the berg's surface was made to detect traces of sediment. The berg surface was pitted with numerous, randomly distributed circular holes approximately 10 - 20 cm wide and up to 0.5 m deep. A few holes were open or partially open at the surface and all were either partially or completely filled with melt water. The top 1 - 2 cm of most holes had been refrozen by clear ice that appeared to have grown radially from the edges to the centre. Holes that were not completely frozen over always had small circular openings in the centre of the new ice (Figure 3). Without exception all of the holes contained flocced organic matter resting on the bottom. Individual flocs were approximately 1 mm in diameter and formed a loose aggregate. Samples were collected by using zip-lock type plastic sample bags to scoop up the flocs which rapidly disintegrated when disturbed.

We believe that this flocced material is cryoconite, a mixture of aeolian dust, blue-green algae and fungi and associated microscopic animals such as rotifers (Dyson, 1969). The reason cryoconite is found in pits is because heat from photosynthesis and metabolism causes the ice to melt, allowing the material to sink downwards. Refreezing of the surface meltwater occurred as the cryoconite sank deeper. It is interesting to note that cryoconite holes are relatively common features below the firm line on the Greenland ice sheet and that

some of the algae colonies there may have developed as long as 200 years (Dyson, 1969).

Strewn over the icesurface were numerous animal bones, mostly of disarticulated seal phalanges. However, one bone showed clear evidence of saw marks indicating that it had come from a joint of meat from a butcher shop. Several bones had become partially or wholly melted into and some had been refrozen in the ice. Other debris included the wrapping from a bologna and a candy wrapper. It seems clear that the berg had been utilized extensively by seabirds which brought their food to a convenient flat surface before devouring it.

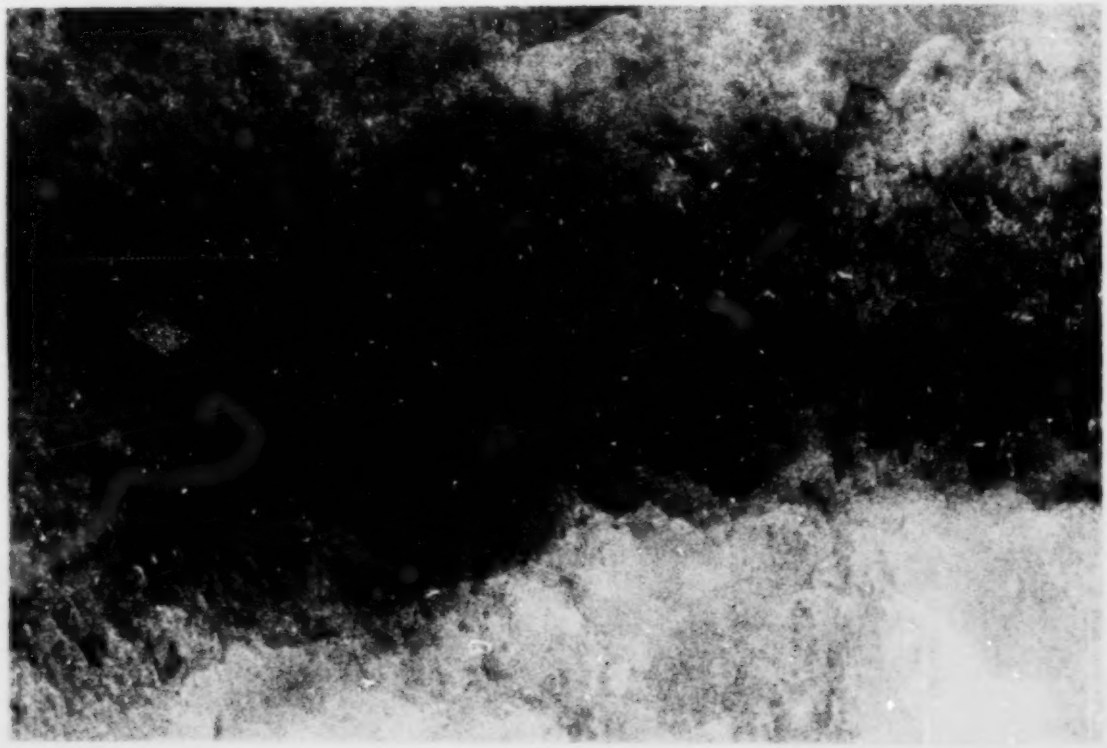

Figure 4 Bifurcating crack showing elongated blue-ice crystals oriented normal to the crack walls and meeting at a well defined septum in the centre.

CRACKS AND FISSURES

Chris Woodworth-Lynas

Numerous parallel-sided, randomly oriented, straight cracks and fissures up to 0.75 m wide were exposed on the berg surface. All of these were composed of blue ice. In several of the bigger cracks two sets of large elongated ice-crystals could clearly be seen oriented normal to the crack edges. Each set met at a septum which was clearly visible in the centre of the crack and was parallel to both crack edges (Figure 4). A non-oriented sample of blue crack ice with a central septum was sampled and kept frozen for later petrographic analysis. It is not known whether the cracks were originally glacier features or were formed subsequent to calving. However, the orientation of the crack ice crystals suggests that most, if not all, cracks were tensional features which dilated at the same time as the blue ice crystals were growing. They appear to have grown in a manner similar to that described by Ramsey and Durney (1973) from dilation cracks in rocks.

WAVE-INDUCED BERGY BIT MOTION - FIELD STUDY

Jim Lever

An attempt was made to record on videocassette the wave-induced motion of bergy bits as viewed from a helicopter. A portable videocassette recorder was used from the helicopter which was employed to shuttle the other members of the group to the iceberg in Freshwater Bay. While an appropriately sized bergy bit (approx. 10 - 15 m across) was found in Outer Cove (entrance to Middle Cove / Torbay), the lack of a significant ocean swell precluded the possibility of recording the wave-induced motion of this ice. It did appear, however, that given more favourable sea conditions, the helicopter would be able to maintain a sufficiently stationary position to allow the motion to be recorded.

Once back on the Freshwater Bay iceberg, motion of small pieces of sea ice in relatively small waves was recorded. This was reasonably successful, although both the ice and wave conditions were considerably scaled down from the bergy bit-in-storm waves phenomenon of primary interest to the authors' current research.

Overall, the trip served to illustrate the difficulties of finding simultaneously an appropriate bergy bit in a large swell in order to monitor wave-induced motion in the field. It is likely that this kind of study would require locating a population of bergs and bergy bits and waiting until sea conditions produced significant swells before recording the

motion. This kind of work should be conducted in conjunction with other longer term field programs in the vicinity of well populated iceberg areas. Hopefully, favourable bergy bit motions in waves would occur which could be monitored at least once during the course of longer field programs.

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